Channels of risk-sharing among Canadian provinces: 1961–2006

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Abstract

This paper incorporates recent developments in the literature to quantify the amount of interprovincial risk-sharing in Canada. We find that 29% of shocks to gross provincial product are smoothed by *capital markets*, 27% are smoothed by the *federal tax-transfer systems*, and about 24% are smoothed by *credit markets*. The remaining 20% are not smoothed. Our results bring to light the critical role that Alberta plays in trading-off credit market smoothing for more capital market risk-sharing with the rest of Canada. Our pairwise risk-sharing analysis has brought up some interesting questions and arguments that are often neglected in discussions of regional risk-sharing. For example, one aspect of the pairwise analysis sheds light on the assessment of the economic effects of Quebec separation.

JEL Classification: C33, E21, F36, H77.

Keywords: Risk-sharing; pairwise risk-sharing; federal taxes and transfer; panel data; cross-sectional dependence.

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1 Introduction

The notion that regions in a federal system can pool together their risks to insure (fully) against idiosyncratic uncertainty in their resources has generated an impressive volume of work in the past two decades. The collection of papers in Hess and van Wincoop (2000) provides a good review of the literature. Our objective in this paper is to quantify the amount of interprovincial risk-sharing in Canada by focusing on both market and nonmarket channels of risk-sharing. The case of Canada comes quite naturally as the provinces constitute a federation with a different division of powers between federal and provincial governments.[1] Most importantly, the Canadian constitution explicitly allows the federal government to contribute to significant smoothing of regional shocks through the system of 'equalization payments', which is designed to address differences in revenue-raising capacity across provinces.[2] This is perhaps why Canadian federalism displays rather strong interprovincial risk-sharing via taxes and intergovernmental transfers than that of the U.S. federal states system (see, *e.g.*, Bayoumi and Masson (1995), Antia et al. (1999) and Méltiz and Zumer (2002)).

In an influential paper, Asdrubali, Sørensen and Yosha (1996) offer an intriguing way of assessing regional risk-sharing via simple decomposition of output that allows to distinguish between two important channels through which risk can be shared: market and nonmarket. The market channel in turn comprises two separate channels, where regions can pool their risk through cross-ownership of productive assets (the "capital" market channel) or through lending or borrowing (the "credit" market channel). The nonmarket channel involves pooling risks by exchanging claims to regional output in the form of equity or through fiscal transfer arrangements (for instance, 'equalization payments' in the Canadian case). In practice, implementation of Asdrubali et al. (1996) method requires regional output, distributed income (before federal government net transfers), disposable income (after the transfer), and consumption. Based on U.S. states data over the period 1963-1990, Asdrubali et al. (1996) find that 62% of shocks to gross state product are smoothed by market channels, whilst only 13% shocks are smoothed by the nonmarket channels. The remaining 25% are not smoothed.

The novelty of Asdrubali et al. (1996) framework is that it has brought together in a single framework important smoothing mechanisms that were often treated separately in the

[1] Data limitation prevents us from including the territories – Northwest Territories, Yukon, and Nunavut – in the analysis.

[2] The Constitution Act of 1982 reaffirms that the federal government is responsible for equalizing the ability of provincial governments to provide comparable levels of public services at comparable levels of taxation. In this respect, Canadian federalism goes well beyond the redistributional objectives of the U.S. federal system. Supplementing the system of equalization payments is the Canada Social Transfer (CST) and Canada Health Transfer (CHT) programs that assist provincial funding in the areas of health, post-secondary education, and social welfare.

literature. For example, Bayoumi and Masson (1995) and Méltiz and Zumer (2002) examine regional risk-sharing through the lens of central government transfers. Atkenson and Bayoumi (1993) work on the attenuation of regional shocks through capital market integration, while Bayoumi and Klein (1997) examine smoothing of regional shocks through the credit market channels. In comparison, Athanasoulis and van Wincoop (1998) center on the capital market and central government channels, while neglecting smoothing via credit markets. In this paper, we make use of the Asdrubali et al. (1996) framework to quantify the amount of interprovincial risk-sharing achieved at each of these levels of smoothing in Canada.

1.1 Related Literature

Several papers (*e.g.*, Bayoumi and Masson (1995), Méltiz and Zumer (1999, 2002), Obstfeld and Peri (1998)) observe that the federal government plays a significant role in stabilization and redistribution in Canada. The range for the federal offset of transitory shocks (*i.e.*, stabilization) is from 9% to 17%, while for permanent shocks (*i.e.*, redistribution), it is from 17% to 53%. These results suggest that redistribution plays a considerably more prominent role in Canada than does stabilization.[3] Overall, these results are a reflection of the influential role of the equalization system as well as the greater preference for national equity standards in Canada.

A classic question in the international and national risk-sharing literature is to what extent the consumption risk differs across regions or countries. According to the theory of aggregate risk-sharing, access to a complete market for financial assets should enable risk-sharing and decoupling of consumption and output among individual households. Crucini (1999) studies this issue by employing panel data that includes the Canadian provinces, U.S. states, and G-7 countries. Crucini (1999) observes that the average estimated risk-sharing parameter tends toward 0.9 (close to the complete risk-sharing benchmark of unity) across Canadian provinces.[4] This result also holds for U.S. states, while the effect is much lower for the G-7 countries.

Antia, Djoudad and St-Amant (1999) measure how much risk-sharing is achieved via different mechanisms (*e.g.*, capital markets, federal taxes and transfers, credit markets) using the framework proposed by Asdrubali et al. (1996). Employing annual data for Canadian provinces from 1962-1995, Antia et al. (1999) find that 37% of the shocks to gross provincial product are smoothed by capital markets, 27% are smoothed by the federal government, and another 27% are smoothed by credit markets. The remaining 14% are not smoothed.

[3]In comparison to the United States, the degree of redistribution is slightly higher in Canada, while the ability of the federal fiscal system to stabilize incomes is roughly the same in the two countries. Vigneault (2002) provides further details.

[4]The province-specific estimate of the risk-sharing parameter ranged from a low of 0.72 for British Columbia, to a high of 0.99 for Prince Edward Island and New Brunswick.

The paper by Antia et al. (1999) is more closely related to our work. However, our approach differs from the existing literature along two important dimensions. First, given the panel nature of the data used, much of the existing literature remains silent on the issue of cross-sectional dependence. Many panel data sets are characterized by dependencies among individuals due for instance to the presence of common shocks, such as changes in oil prices. Accounting for cross-sectional dependence in the estimation procedure is crucial, since ignoring the cross-sectional correlation is known to cause severe size distortion, so that the power gain delivered by the panel dimension, is entirely fictitious. We incorporate the potential cross-sectional dependence due to common shocks hitting different provinces at the same time.

Consequently, we apply the Driscoll and Kraay (1998) panel data estimator that is robust to very general form of temporal and cross-sectional dependence. Their approach consists of applying a standard nonparametric heteroscedasticity and autocorrelation consistent (HAC) variance estimator to the cross-sectional average of the moment conditions identifying the parameter of interest. The consistency of the standard errors is established under the assumption of large T asymptotic, independently of the panel's cross-section dimension N. This is a desirable property given the short cross-section dimension of our panel data (*i.e.*, $N = 10$). The simulation results in Driscoll and Kraay (1998) and Hoechle (2007) show that, when cross-sectional dependence is present, the Driscoll and Kraay (1998) standard errors dominate alternative standard errors such as least squares, White (1980) and Newey and West (1987) that assume cross-sectional independence across individuals of the panel.

Second, we extend our *overall* risk-sharing accounting into the dimension of *pairwise* (or bilateral) risk-sharing, which allows to quantify the extent of risk-sharing for all possible pairs in the panel.[5] One limitation of the overall existing approach is that it says nothing about which partner a particular province shares risk with. For example, effective risk-sharing between Quebec and Ontario might be virtually nonexistent, as they are both specialized in manufacturing industries and may have highly correlated income as a result. In fact, these two provinces might be sharing risk with potentially different third parties, rather than with each other. This possibility motivated us to examine the risk-sharing in a bilateral context. Recently, Imbs (2005) and Fratzscher and Imbs (2009) implement the concept of bilateral risk-sharing on international data, in this paper intra-national data are brought to the issue.

The remainder of the paper is organized as follows. Section 2 presents the variance decomposition of output, while Section 3 discusses the econometric issues. Section 4 presents data and main empirical results. Section 5 outlines the pairwise approach in more detail and discusses

[5]This paper takes pairwise risk-sharing and bilateral risk-sharing as synonymous.

the results. Section 6 concludes.

2 Channels of Risk-Sharing: Decomposing the Cross-Sectional Variance of Shocks to Provincial Output

This section provides an overview of the Asdrubali et al. (1996) framework relating to the variance decomposition of output. Suppose we have a panel data for per capita provincial output GPP_i (where i stands for the individual province), per capita provincial income PI_i, per capita provincial disposable income PDI_i, and per capita provincial consumption $\text{C}_i + \text{G}_i$ (private and public consumption), all stated in real terms. Let us begin with the identity,

$$\text{GPP}_i = \frac{\text{GPP}_i}{\text{PI}_i} \frac{\text{PI}_i}{\text{PDI}_i} \frac{\text{PDI}_i}{(\text{C}_i + \text{G}_i)} (\text{C}_i + \text{G}_i). \tag{1}$$

To stress the cross-sectional nature of our derivation, we suppress the time index. Taking logs and differences on both sides of (1), multiplying both sides by $\Delta \log \text{GPP}_i$, and taking expectations, we obtain the variance decomposition in $\Delta \log \text{GPP}_i$,

$$\begin{aligned} \text{var}\{\Delta \log \text{GPP}_i\} \quad = \quad & \text{cov}\{\Delta \log \text{GPP}_i - \Delta \log \text{PI}_i, \Delta \log \text{GPP}_i\} \\ & + \text{cov}\{\Delta \log \text{PI}_i - \Delta \log \text{PDI}_i, \Delta \log \text{GPP}_i\} \\ & + \text{cov}\{\Delta \log \text{PDI}_i - \Delta \log(\text{C}_i + \text{G}_i), \Delta \log \text{GPP}_i\} \\ & + \text{cov}\{\Delta \log(\text{C}_i + \text{G}_i), \Delta \log \text{GPP}_i\} \ . \end{aligned}$$

In the above equation var{X} and cov{X,Y} denote the statistics $\frac{1}{N}\sum_{i=1}^{N}(\text{X}_i - \bar{\text{X}})^2$ and $\frac{1}{N}\sum_{i=1}^{N}(\text{X}_i - \bar{\text{X}})(\text{Y}_i - \bar{\text{Y}})$, respectively, where N is the number of Canadian provinces. Dividing (1) by $\text{var}\{\Delta \log \text{GPP}_i\}$ we get $1 = \beta_k + \beta_f + \beta_c + \beta_u$, where, for example,

$$\beta_k = \frac{\text{cov}\{\Delta \log \text{GPP}_i - \Delta \log \text{PI}_i, \Delta \log \text{GPP}_i\}}{\text{var}\{\Delta \log \text{GPP}_i\}},$$

is the slope in the cross-sectional regression of $\Delta \log \text{GPP}_i - \Delta \log \text{PI}_i$ on $\Delta \log \text{GPP}_i$, and similarly for β_f, and β_c. The last coefficient in the decomposition is given as,

$$\beta_u = \frac{\text{cov}\{\Delta \log(\text{C}_i + \text{G}_i), \Delta \log \text{GPP}_i\}}{\text{var}\{\Delta \log \text{GPP}_i\}},$$

is the slope in the cross-sectional regression of $\Delta \log(\text{C}_i + \text{G}_i)$ on $\Delta \log \text{GPP}_i$.

The coefficients β_k, β_f and β_c are interpreted as the fraction of shocks absorbed through capital markets, federal tax-transfer system, and credit markets, respectively; whereas the coefficient β_u denotes the fraction of shocks to provincial GPP that is not smoothed. If perfect risk-sharing exists, these coefficients add to unity and $\beta_u = 0$. If not, they sum to less than unity.[6] The sum of β_k and β_c constitutes the fraction of shocks smoothed through market transactions. Nevertheless, β_k differs from β_c in that the former is the result of *ex ante* arrangement, prior to the occurrence of shocks, whereas the latter takes place *ex post*, after shocks occurs. Asdrubali et al. (1996) argue that capital market (β_k) can provide insurance against persistent as well as transitory shocks; whereas credit market (β_c) typically smooth only transitory shocks, since lenders in other provinces might be reluctant to grant credit to provinces that are hit by shocks that are expected to persist.

We do not impose any restrictions on the sign of the β-coefficients. If a province that is hit by a positive shock has a smaller share of GPP allocated to, *e.g.*, through credit markets, then savings might provide cross-sectional dis-smoothing. Similarly, if taxes increase or decrease less than proportionately with output, they generate dis-smoothing.

3 Econometric Issues

Following equation (1), at the practical level, the panel equations are estimated as follows,

$$
\begin{aligned}
\Delta \log \widetilde{\mathrm{GPP}_{it}} - \Delta \log \widetilde{\mathrm{PI}_{it}} &= \alpha_k + \beta_k \Delta \log \widetilde{\mathrm{GPP}_{it}} + e_{ikt}, \text{ (capital market smoothing)}, && (2)\\
\Delta \log \widetilde{\mathrm{PI}_{it}} - \Delta \log \widetilde{\mathrm{PDI}_{it}} &= \alpha_f + \beta_f \Delta \log \widetilde{\mathrm{GPP}_{it}} + e_{ift}, \text{ (federal govt. smoothing)}, && (3)\\
\Delta \log \widetilde{\mathrm{PDI}_{it}} - \Delta \log \widetilde{(\mathrm{C}_{it} + \mathrm{G}_{it})} &= \alpha_c + \beta_c \Delta \log \widetilde{\mathrm{GPP}_{it}} + e_{ict}, \text{ (credit market smoothing)}, && (4)\\
\Delta \log \widetilde{(\mathrm{C}_{it} + \mathrm{G}_{it})} &= \alpha_u + \beta_u \Delta \log \widetilde{\mathrm{GPP}_{it}} + e_{iut}, \text{ (unsmoothed component)}, && (5)
\end{aligned}
$$

where $i = 1, 2, ..., N$ and $t = 1, 2, ..., T$ denote cross-section and time series dimension, respectively. A tilde ($\sim$) over a variable denotes its log deviation from its aggregate component. For example, $\Delta \log \widetilde{\mathrm{GPP}_{it}}$ is measured as $\Delta \log \mathrm{GPP}_{it} - \Delta \log \mathrm{GPP}_t$, where $\Delta \log \mathrm{GPP}_{it}$ denotes the growth rate of province i's GPP per capita and $\Delta \log \mathrm{GPP}_t$ denotes the growth rate of the group's aggregate GPP per capita. The reason for removing aggregate output fluctuations from province-level fluctuations is to isolate the smoothable output fluctuations. Panel estimation of equations (2)–(5) involves several challenges. In the case of panel data models where the cross-section dimension (N) is small and the time series dimension (T) is large, it is typical

[6] Likewise, if risk-sharing is achieved through capital market alone, $\beta_k = 1$; while $\beta_k + \beta_f = 1$ if risk-sharing is achieved through the combination of capital market and federal transfers smoothing, and so on for any other combination. The bottom line is that these coefficients reflect the incremental amount of smoothing achieved through the various channels discussed above.

to treat the equations from the different cross-section units as a system of seemingly unrelated regression equations (SURE) and then estimate the system by generalized least squares (GLS) techniques. This is the approach used by Asdrubali et al. (1996) and maintained in the subsequent literature. The main limitation of this approach is that it is based on the assumption of cross-sectional independence, such an assumption is far from realistic.[7]

There are clearly many channels through which residuals of the panel regressions can be contemporaneously correlated. In particular, they could be due to common observed global shocks (such as changes in oil prices), they could arise as a result of global unobserved factors (such as the diffusion of technological progress), or could be due to specific national or sectoral shocks. Whilst the presence of common shocks is likely to generate dependence among individuals in the panel, their impact may not be the same across different cross-section units. Accounting for cross-sectional dependence is crucial in order to obtain consistent estimates of the standard errors of the regression parameters. Besides the cross-sectional dependence, we might also expect the errors to show heteroscedasticity and serial correlation.

The main essence of a panel estimator, in the presence of nonspherical errors, is the consistent estimator of the covariance matrix. Standard estimators such as White (1980) Newey and West (1987) are useful to correct for heteroscedasticity and autocorrelation, however, they do not correct for cross-sectional correlation. In this respect, Driscoll and Kraay (1998) propose a nonparametric covariance matrix estimator which produces heteroscedasticity consistent standard errors that are robust to very general form of contemporaneous and temporal dependence.[8] Driscoll and Kraay (1998) point out that the panel data inference problem with general serial patterns and spatial correlation can be thought of as a time-series problem in the cross-sectional *averages* of the products of the regressors and error terms, $h_{it}(\hat{\theta}) = x_{it}\hat{e}_{it}$, then the relevant cross-sectional average for period t is $h_t(\hat{\theta}) = (1/N)\sum_{i=1}^{N} h_{it}(\hat{\theta})$, where $\hat{\theta}$ is a $K \times 1$ vector of estimated parameters. The time series behavior of these averages are accounted for when constructing the covariance matrix, and Driscoll and Kraay (1998) provide the specific conditions where standard Newey-West technique can be applied.

Essentially, the Driscoll and Kraay's (1998) covariance matrix estimator equals the heteroskedasticity and autocorrelation consistent covariance matrix estimator of Newey and West (1987) applied to the time series of cross-sectional averages of the $h_{it}(\hat{\theta})$. By relying on cross-

[7] The standard approach of cross-sectionally de-meaning the data does not solve the problem in heterogenous panels since common shocks may impact differently on each cross-section.

[8] Other estimators in the literature that attempt to correct for heteroscedasticity as well as for temporal and spatial dependence are Parks (1967) and Beck and Katz (1995). However, these estimators can only handle first-order autoregressive type of dependence, and therefore are not robust to very general form of cross-section as well as temporal dependence. Moreover, these procedures rely on parametric models to estimate the covariance matrix, which may be too restrictive in some cases.

sectional averages, standard errors estimated by this approach are consistent independently of the panel's cross-sectional dimension N. Driscoll and Kraay (1998) use mixing random fields which encompass a broad class of contemporaneous and temporal dependence that are typically present in panel data. Monte Carlo simulations in Driscoll and Kraay (1998) and Hoechle (2007) show that failure to correct for cross-sectional dependence yields large biases to least squares standard errors. Furthermore, Hoechle (2007) shows that the coverage rates of Driscoll-Kraay standard errors are almost invariant to changes in the level of cross-sectional and temporal correlation. In order to test whether or not errors are cross-sectionally dependent, we use the well-known Breusch and Pagan (1980) Lagrange Multiplier (LM) statistic.

4 Empirical Results

4.1 Data

The primary source of our data is Statistics Canada (CANSIM database), which records national accounts data by provinces. The data span is from 1961 to 2006 and are expressed in Canadian dollars. Per capita figures are obtained by normalizing by the population for each province. Our major variables are: gross provincial product (GPP_i), provincial income (PI_i), provincial disposable income (PDI_i) and consumption ($\text{C}_i + \text{G}_i$). All series are expressed in real per capita terms.

These above variables are collected for all 10 provinces: Newfoundland and Labrador (NL), Prince Edward Island (PE), Nova Scotia (NS), New Brunswick (NB), Quebec (QC), Ontario (ON), Manitoba (MB), Saskatchewan (SK), Alberta (AB) and British Columbia (BC). Detailed definition of the variables and their sources are provided in the Appendix.

4.2 Main Results

Our empirical analysis begins by conducting the unit root test for all series. As the Driscoll and Kraay (1998) procedure is intended for stationary panels, it is important that the series do not exhibit unit root behavior. To this end, we apply the cross-sectionally augmented ADF (CADF) statistics proposed by Pesaran (2007) that allows for cross-sectional dependence. The CADF test models cross-sectional dependence by augmenting the standard ADF regressions for the individual series with current and lagged cross-section averages of all the series in the panel. Results indicate that for all series, the null hypothesis of a unit root is strongly rejected, validating our approach. In the interests of brevity, unit root test results are not reported but are available on request.

Table 1 displays the main empirical results. From Panel A in Table 1, it is apparent that the extent of risk-sharing among Canadian provinces is high, as only 20% of shocks to gross provincial product are not insured. The statistical significance of the unsmoothed coefficient (β_u) suggests that the null hypothesis of full interprovincial risk-sharing is strongly rejected. Our breakdown shows that both capital markets and the federal tax-transfer systems play an almost equally important role in smoothing shocks to gross provincial product, which is an indication of the prominent role that the federal government has played in Canada, in comparison to, say, the United States. The amount of smoothing at the last level, which we refer to as credit market smoothing, is nearly 24% and is clearly statistically significant like other components. The total amount of smoothing through capital and credit markets is therefore 53% which clearly dominates the 27% smoothed by the federal government. Unreported results show that the Breusch and Pagan (1980) LM statistic strongly rejects the null hypothesis of no cross-sectional dependence at the 1% level, hence validating the use of Driscoll-Kraay procedure. Our finding is different from earlier studies in many respects. For example, Antia et al. (1999) find a relatively smaller estimate of β_u, and observe a higher estimate for β_k and β_c. In a nutshell, the differences between our results and those in previous studies are partly attributable to data as well as methodological improvements.

We also conducted an analysis after dropping Alberta from the sample. Alberta is supported by a burgeoning petroleum industry with one of the highest per capita gross domestic product (GDP) in the world. In 2005, Alberta's per capita GDP reached $66,275, nearly double the $33,553 Canadian average income in 1995. This was 56% above the national average and more than twice incomes in some of the Atlantic provinces.[9] Panel B in Table 1 shows a reduction in capital market smoothing to 20%, which appears to be compensated by a rise in credit market smoothing to nearly 37%. We will come back to this issue in the next section. Not surprisingly, smoothing via federal transfers drops to about 21%, as Alberta is a net contributor to the equalization payments. The unsmoothed part slightly increases to 22%. Once again, (unreported) LM test statistic strongly rejects the null hypothesis of cross-sectional independence.[10]

4.3 Subperiods

To get a feel for the changes in the levels of smoothing through markets and fiscal federalism over time, we repeated the above analysis over four subperiods, as reported in Table 2. An important finding is that over the years there has been a considerable increase in capital mar-

[9] Cross and Bowlby (2006).

[10] Empirical results allowing for province-specific fixed effects (where in equations (2)-(5) the constant α_i is allowed to differ across provinces) are very similar to those presented in Table 1 and hence not presented here to save space. These unreported results are available from the corresponding author on request.

ket smoothing, whereas the amount of credit market smoothing declined remarkably. As can be seen, during the past three decades over one-third of a shock to gross provincial product was smoothed by capital markets. Over the postwar period the Canadian banking system has underwent major regulatory and market-driven changes.[11] For example, the 1967 amendments to the Bank Act eliminated the 6% ceiling on interest rate on bank loans; the 1987 legislative changes effectively eliminated the Canadian equivalent of the U.S. Glass-Steagall Act, which had previously prohibited banks from participating in the securities business. Naturally, these changes in the financial landscape have not only widened Canadian commercial banks' access to asset markets,[12] they have also made it easier for Canadian households to smooth out consumption in the desired way. As banks play a central role in the allocation of capital in the economy, greater financial integration across jurisdictions, as a result of banking deregulation, would allow households to trade claims on output (*e.g.*, equity or direct investment) across provincial borders, thereby sharing province-specific risks with residents of other provinces. We feel that a deeper examination of the effects of banking deregulations is an interesting topic for further research, but nevertheless we dare speculate that the persistent increase in capital market smoothing is a consequence of better financial regulation and policy implemented in the Canadian banking industry.

By contrast, the large amount of smoothing via credit market during 1962-1970 is clearly a reflection of the very high concentration with a few large banks holding most of the assets within the sector (Dean and Schwindt, 1976). However, beginning 1970s, this picture had started to change. While Canadian banks have traditionally been important players in the domestic markets, their involvements in the foreign markets were equally important. For example, Canadian banks' foreign currency assets as a percentage of total assets rose from about 15% in the late 1950s to a high of 46% in the mid-1980s before falling back to around 38% in late 1990s (Freedman, 1998). Much of growth in 1970s and 1980s reflected Canadian banks' increasing involvement in the burgeoning Euro-markets as well as lending to less-developed countries. As a result, direct lending to domestic business and consumers suffered, whilst banks' participation in the rapidly growing securities market increased heavily. For example, in 1996, investment banking and other securities fees contributed over one-quarter of "other income" for the six largest Canadian banks (Freedman, 1998). We believe that this changing role of the Canadian banks, which went from traditional operations of deposits and lending to security activities,

[11] The "sunset" clause in Canadian banking legislation requires a periodic reassessments and updating of the laws governing Canadian bank. As a result, the financial system in Canada has undergone a series of Bank Act amendments in 1954, 1967, 1980, 1987, 1992, and 1997.

[12] For example, prior to 1987 banks won about 15% of treasury bill auctions and 19% of Government of Canada bond auction. In 1996, the comparable number for banks climbed to 62% and 50%, respectively (Freedman, 1998).

has been the major contributing factor behind the rise in capital market and the fall in credit market smoothing in Canada over the past forty years.

In cases where market mechanisms (*e.g.*, credit smoothing) fail to stabilize regional output and employment, intergovernmental transfer mechanisms can contribute to smoothing cyclical movements resulting from region-specific shocks to output. Indeed, the decrease in credit market smoothing appears to be partially compensated for by an increase in federal smoothing during 1970s and 1980s. During these years, federal government spending on social services[13] increased dramatically, causing chronic, large-size budget deficits. In fact, despite the rising tax rates, budget revenues failed to match government expenditure resulting an immense escalation of public debt and the corresponding interest charge on public debt. After reaching peak in 1996-97, the debt-to-GDP ratio started to decline following tightening of budgetary spending and a change in the general approach to public management policy, implemented by the Liberal government, headed by Jean Chrétien. The fall in federal smoothing in the 1990s is clearly a reflection of the wider program of spending restraint of the Chrétien era.[14]

Finally, Figure 1 plots a kernel estimate of the different levels of smoothing.[15] The stacked area chart displays the corresponding type of smoothing for the entire sample. The area under the uppermost curve is the amount left unsmoothed after capital market smoothing, the area under the curve below is the amount left unsmoothed after capital market plus federal smoothing, and the area under the bottom curve is the amount eventually left unsmoothed. As can be seen, the trends described above are clearly visible.

5 Pairwise Risk-Sharing

The preceding analysis has focused on the extent of overall risk-sharing, which says nothing about which partner a particular province shares risk with. This section evaluates the channels of risk-sharing in a bilateral context. This corresponds to $N(N-1)/2$ or 45 pairwise combinations comprising the 10 provinces. There are several reasons why the bilateral risk-sharing is an attractive alternative to the overall risk-sharing presented above. First, the pairwise approach is not sensitive to a particular benchmark time series. As seen above, the distribution of the amount of insured shocks changes remarkably when Alberta is excluded from the analysis. This limitation is easily avoided by considering the pairwise approach. Second, in addition to quantifying the amount of risk-sharing between any two pairs, i and j, $i \neq j = 1, 2, ..., N$; the

[13]Some important categories include spending on equalization payments, CST, CHT, (un)employment benefits, old age security, and child tax benefits.

[14]Another possibility is the pro-cyclical budgetary characteristics of the federal government which prevent functioning of automatic stabilizers during economic downturns. See CGA-Canada (2008) for further discussion.

[15]Each curve is constructed using the methodology described in Asdrubali et al. (1996, p. 1095).

pairwise approach can be exploited further to quantify the amount of risk-sharing between any region i and the rest of the country (*i.e.*, $N-1$). This will help us to determine, by province, the portion of shocks that are smoothed locally, as risk diversification may well happen in partnership with the rest of the world. Third, as emphasized in the introduction, bilateral risk-sharing between two specialized provinces such as Quebec and Ontario may be absent due to their highly correlated incomes, risk-sharing in these two provinces might happen with potentially different third parties. Our interest in quantifying bilateral risk-sharing is further motivated by the recent findings that Canadian regional output fluctuations are driven by an asymmetric and economically important set of disaggregate propagation and growth mechanisms (Wakerly et al., 2006). In other words, Canadian regions seem not to respond symmetrically to the same aggregate shock,[16] thereby weakening the notion that the regions of Canada form an optimal currency area (OCA) in the sense of Mundell (1961) – see Wakerly et al. (2006) for further details.

Equations (2)–(5) are extended to make them applicable to a bilateral context. In particular, we estimate,

$$\begin{aligned}
\Delta \log \text{GPP}_{ijt} - \Delta \log \text{PI}_{ijt} &= \alpha_k + \beta_k \Delta \log \text{GPP}_{ijt} + \gamma_k \Delta \log z_t + e_{ijkt}, \qquad (6)\\
\Delta \log \text{PI}_{ijt} - \Delta \log \text{PDI}_{ijt} &= \alpha_f + \beta_f \Delta \log \text{GPP}_{ijt} + \gamma_f \Delta \log z_t + e_{ijft}, \qquad (7)\\
\Delta \log \text{PDI}_{ijt} - \Delta \log(\text{C}_{ijt} + \text{G}_{ijt}) &= \alpha_c + \beta_c \Delta \log \text{GPP}_{ijt} + \gamma_c \Delta \log z_t + e_{ijct}, \qquad (8)\\
\Delta \log(\text{C}_{ijt} + \text{G}_{ijt}) &= \alpha_u + \beta_u \Delta \log \text{GPP}_{ijt} + \gamma_u \Delta \log z_t + e_{ijut}, \qquad (9)
\end{aligned}$$

where, for example, $\Delta \log \text{GPP}_{ijt}$ is measured as $\Delta(\log \text{GPP}_{it} - \log \text{GPP}_{jt})$; z_t is a vector of control variables which includes the growth rate of the Canadian output per capita and world output per capita (in real terms).[17] As the United State is the largest trading partner of Canada, we use the US output as a proxy for the world output.[18] The description of the other parameters and variables is explained above. Notice the possibility that Quebec and Ontario choose to insure income with third parties rather than with each other is accounted for through the presence of the "output gap" term, $\Delta \log \text{GPP}_{ijt}$. Equations (6)–(9) spell out the necessary condition for perfect, bilateral risk-sharing between provinces i and j. Thus, when $\beta = 1$ the pair of provinces

[16]Scott (2001) provides similar evidence. He reports that the transitory component of Canadian regional outputs respond asymmetrically to money demand shocks.

[17]Needless to say, the regression specifications in equations (6)–(9) are far from complete, we expect future research to study these issues in greater detail.

[18]The United States and Canada conduct the world's largest bilateral trade relationship, with total merchandise trade (exports and imports) exceeding \$499.3 billion in 2005. The United States supplied 56.6% of Canada's imports of goods in 2005, and purchased 84% of Canada's merchandise exports. Nearly 80% of the Canadian population lives within the 200 miles of the U.S. border and both countries are partners with Mexico in the North American Free Trade Agreement (NAFTA). See Fergusson (2006) for further details.

fully share risk with each other, whereas when $\beta = 0$ the pairs do not share risk with each other but with the rest of Canada. Following Fratzscher and Imbs (2009), the extent of bilateral risk-sharing is identified via a panel dimension, although here each individual observation corresponds to a provincial pair and the panel traces the time variation between dependent and independent variables for each provincial pair.[19] As before, the system is estimated using the Driscoll-Kraay procedure. It is worth mentioning that measurement errors are not a relevant issue in the estimation of equations (6)–(9), since the variables are part of province-level "national accounts". For brevity, only the estimated pairwise coefficients are presented in Tables 3–7, full details are available from authors' on request.

Table 3 reports the pairwise risk-sharing through capital markets. An interesting result that emerges is the prominent role played by Alberta in regional risk-sharing via capital market mechanisms. Save for Saskatchewan, the remaining eight provinces are seen to smooth shocks significantly with Alberta. This is perhaps an indication of low correlation of output between Alberta and other provinces, whereby Alberta's oil-based economy provides greater opportunity for risk-sharing for the regional non-oil economies.[20] This result is consistent with our main results (Table 1), which show that excluding Alberta from the analysis significantly weakens the capital market channel. Among the four easterly provinces, Nova Scotia and New Brunswick fare much better compared with Newfoundland and Labrador and Prince Edward Island in offsetting asymmetric shocks to output with their western counterparts. Nevertheless, the largest amount of shocks, among all possible provincial pairs, absorbed through capital market between Nova Scotia and New Brunswick is eye-catching. This is perhaps due to their dissimilar economic structures, in which the service sector dominates Nova Scotia's economy, while New Brunswick is the third most manufacturing-intensive economy of Canada, after Quebec and Ontario. Several provincial pairs (*e.g.*, Quebec-Manitoba) exhibit a dis-smoothing through capital market, although they are not statistically significant.

Table 4 presents the estimates of pairwise risk-sharing through federal tax-transfers sys-

[19]It is worth mentioning here that the analysis of bilateral risk-sharing at the macro level had not previously ventured in the literature for at least two reasons: (a) the difficulty of isolating the estimation from external omitted disturbances and (b) the difficulty of isolating the estimation from intertemporal effect. While the first issue is partially addressed here by means of controlling for omitted effects, the second issue is more difficult to deal with. This is because of the difficulties associated with capturing the effect of aggregate output growth and the treatment of individual heterogeneity in a bilateral setting. Such problems are easier to deal with within the context of a panel data as demonstrated by Asdrubali and Kim (2008). Hence, the coefficient estimates of our pairwise regressions cannot strictly be interpreted as evidence of the degree of risk-sharing, as some amount of shocks are also absorbed through exchanges of risk over time (*i.e.*, intertemporal smoothing). We thank the anonymous referee for pointing this out.

[20]Like Alberta, resource sectors (mainly oil and gas) dominate Newfoundland and Labrador's economy. However, unlike Alberta, the contribution of oil and gas to Newfoundland and Labrador's economic growth is a recent phenomenon, which may explain why the relationship (*i.e.*, equation (6)) between the two provinces was not affected.

tem. By eyeballing the estimates, we can readily see that there is much evidence of bilateral risk-sharing among Canadian provinces. Save for New Brunswick, nearly all provincial pairs exhibit significant evidence of risk-sharing through federal tax-transfer system. This is to be expected as the system of federal government transfers are designed to offset uneven fiscal capacities across provinces. Among the various transfer mechanisms, the system of equalization payment appears to be very relevant, as it provides both redistributive and stabilization roles of fiscal transfers. Under this system, federal funds are distributed from the "have"[21] to the "have not"[22] provinces to address differences in revenue-raising capacity across provinces (the 'redistributive' role), while simultaneously insuring recipient governments against cyclical, adverse fiscal conditions affecting them on a short-term basis (the 'stabilization' role). Quoting Smart (2004): 'equalization is sometimes called the "glue" that holds the Canadian federation together.' On the other hand, the case of bilateral risk-sharing through federal transfers among the three rich provincial pairs (*i.e.*, ON-AB, ON-BC, and AB-BC) can be interpreted in relation to other transfer mechanisms such as the CST and CHT programs, which are calculated on an equal per capita cash basis to ensure government's commitment to provide equal support for all Canadians. For all other provincial pairs, all means of federal transfer programs would be contributors to the pairwise risk-sharing observed.

The estimates of pairwise risk-sharing through credit market are presented in Table 5. First, we observe that none of the provinces (except Saskatchewan) share risk with Alberta by means of credit markets. Recall that these were the same provinces that exhibited very strong evidence of risk-sharing with Alberta through capital markets. Taken this way, Alberta offers a trade-off between capital and credit markets smoothing to the rest of Canada. Put differently, Alberta is reluctant to grant credit to other provinces during economic downturn, while it is a safe-haven for these provinces to smooth their incomes through capital markets. By contrast, Saskatchewan's strong evidence of credit risk-sharing with Alberta can be interpreted in light of high out-migration from the former to the latter. For example, from 1971/72 to 2006/07, each year on average nearly 1.20% of Saskatchewan population migrated to Alberta, the highest among Canadian provinces.[23] It is quite natural for workers in Saskatchewan to leave their families to look after the farm, while the male heads migrate to Alberta for better employment opportunities. Likewise, Alberta has benefitted from out-migration from neighboring provinces. Therefore, it is possible that individuals from Saskatchewan might have built credit records in Alberta that make it easier for them to access credit in bad times.

[21]Ontario, Alberta, and British Columbia.
[22]Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick, Quebec, Manitoba, and Saskatchewan.
[23]Source: authors' calculations based on CANSIM Tables 051-0001 and 051-0019.

Table 6 displays the estimates of pairwise coefficients representing the unsmoothed risk component. The most striking aspect of interprovincial risk-sharing is the large and significant point estimate of the pairwise coefficient between Quebec and Ontario, indicating that a significant fraction of shocks between the two neighboring provinces has not been smoothed. On the surface this may seem surprising given the remarkable interdependence of trade between Quebec and Ontario. For example, in 1996 about 58% of Quebec's interprovincial exports went to Ontario, whereas about 40% of Ontario's exports were sent to Quebec markets (Page, 2002). To shed light on the possible reasons behind the large unsmoothed part, in Figure 2 we have plotted real GDP per capita and its growth rates for Quebec and Ontario over the period 1962-2006. As can be seen, outputs of both provinces appear to move together, where Quebec's output has historically been lower than that of Ontario. Moreover, the growth rates of their outputs appear equally volatile and seem to move together. In fact, based on 1965-2002 regional outputs data, Wakerly et al. (2006) observe strong comovement in trends and cycles in Quebec and Ontario outputs. Taken together, these results suggest that the extent of risk-sharing between Quebec and Ontario is low because of high degree of co-fluctuations of output between them, risk-sharing happens via other provinces.[24] On the other hand, a good number of provinces display significant evidence of unsmoothed shocks with British Columbia. Perhaps distance is a factor behind this result, as British Columbia is the most westerly province in Canada. Estimates of the unsmoothed component for several economically poor provincial pairs (*e.g.*, PE-QC, NS-MB) are low, although these estimates are all statistically insignificant, one can get a feel that further scope of risk-sharing among these provinces are limited.

To take advantage of the bilateral approach characterizing the dynamics of interprovincial risk-sharing, we have proceeded to compute the fraction of shocks smoothed by a particular province with the rest of Canada–which is defined as the sum of outputs of the ten provinces less the province in question. In regressions (6)–(9), this is obtained by defining subscript j as the rest of Canada. We call these models "multilateral" test of risk-sharing.[25] The United States output growth per capita is used as a control variable. The results are presented in Table 7, which only reports the estimated pairwise coefficients. Several comments are in order. First, the amount of shocks smoothed through capital market is higher among economically poorer provinces (*e.g.*, Nova Scotia) than richer provinces (*e.g.*, Ontario). It is possible that richer provinces are more financially integrated with international than national financial markets. For example, a significant portion of Alberta's "Heritage Savings and Trust Fund", which aims

[24] There is an old literature examining business cycle patterns between Quebec and Ontario. See Raynauld (1988) and the references therein for discussion on this subject.

[25] Like the bilateral test in equations (6)–(9), the extent of multilateral risk-sharing is also identified via a panel dimension.

to generate greatest financial returns on those savings for Albertans, comprises bond and equites of international markets. Second, the extent of federal government smoothing between each Canadian province and the rest of Canada is surprisingly similar. This is an indication of a well-designed federal transfer system. Third, save for Alberta, the credit channel is not working for any of the provinces. Since credit market smoothing is a result of *ex post* arrangements, insurance after the occurrence of shocks is nonexistent. This poses a puzzle concerning the Canadian economic union which is generally assumed to be much tighter than its US and European counterparts. Finally, it is very interesting to observe that Quebec (after Nova Scotia) smoothes the largest fraction of shocks to gross provincial production with the rest of Canada. This has important implications relating to the assessment of the economic effects of Quebec separation. If national boundaries are such an important determinant of income and consumption smoothing in Quebec, the ability to maintain the existing risk-sharing with the rest of Canada after separation becomes both more important and more uncertain.[26]

Summing up, the pairwise approach sheds many important micro details that are often left out when focusing on the overall (risk-sharing) approach. It offers a richer insight as to the ability or lack thereof of individual provinces to weather the storm by leaning on inherent market mechanisms and/or fiscal federalism. It also tenders decision makers a better springboard for income redistribution, be it for time of economic downturns or for the usual equalization payment scheme.

6 Conclusions

We have examined the extent of risk-sharing among Canadian provinces using both market and nonmarket channels employing data over the period 1961-2006. Several interesting findings emerge from the analysis. First, both capital market and the federal tax-transfer system play an almost equally important role in smoothing shocks to gross provincial product. This result highlights the influential role played by the federal government in buffering asymmetric regional shocks. Second, while nearly 24% of shocks are smoothed by credit market, this channel does not lend evidence of significant risk-sharing bilaterally/multilaterally. A decade-by-decade analysis reveals that smoothing via capital market has persistently increased, while the credit channel became less and less important. We speculate this trend as a consequence of several postwar regulatory changes in the Canadian banking industry. Finally, the pairwise analysis brings up several important details about the extent and nature of interprovincial risk-sharing,

[26] Helliwell (1996) observes a similar outcome using merchandise trade flows among Canadian provinces and between Canadian provinces and U.S. states. He finds that Quebec trades twenty times more with other Canadian provinces than it does with other U.S. states of similar size and distance.

which has not been analyzed with regional data. The pairwise approach offers a new dimension to understanding regional risk-sharing that can help decision makers in formulating policies to remedy the weak links of incomplete risk-sharing.

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A Data Appendix

The sample period begins in 1961 and extends to 2006. The data were extracted from Statistics Canada's CANSIM database. Detailed definition and exact source for each series is provided below.[27] Save for CPI and population data, all figures are in millions of Canadian dollars. The data are available from the corresponding author on request.

Gross provincial product
Gross domestic product is taken from CANSIM Table 384-0035 for the years 1961-1980 and from Table 384-0035 for years 1981-2006. Provincial GDP is then divided by its own CPI followed by population to arrive at real GDP per person. Canadian real GDP per capita is defined as the sum of the ten provinces' GDP, divided by Canadian CPI and then divided by the sum of ten provinces' populations.

Provincial income
It is calculated as follows:

	Personal income
−	Federal transfers to persons
−	Federal transfers to provincial and local governments
=	Provincial income

The source of personal income is similar to that reported for GDP. Federal transfer to persons is taken from CANSIM Table 384-0022 for the years 1961-1980 and from Table 384-0004 for years 1981-2006. Federal transfer to provincial and local governments is taken from CANSIM Table 384-003 for the years 1961-1980 and from Table 384-0011 for years 1981-2006. Provincial income is divided by its own CPI and then by population to arrive at real provincial income per person. Canadian income is calculated in a similar way as Canadian GDP.

Provincial disposable income
It is calculated as follows:

	Personal income
−	Direct taxes from persons to federal government
−	Direct taxes from corporations to federal government
−	Indirect taxes
+	Other current transfer from persons
=	Provincial disposable income

Source of personal income is mentioned above. The other remaining items were taken from the similar CANSIM Tables as *federal transfers to persons* (mentioned above). Provincial disposable income is divided by its own CPI and then by population to arrive at real provincial disposable income per person. Canadian disposable income is calculated in a similar way as Canadian GDP.

[27] We have followed similar data definitions as Antia et al. (1999).

Consumption

	Personal expenditure on consumer goods and services
+	Government current expenditure on goods and services
=	Total consumption

Both consumption items are taken from CANSIM Table 384-0015 for the years 1961-1980 and from Table 384-0002 for the years 1981-2006. Total consumption is divided by its own CPI and then by population to arrive at real provincial income per person. Canadian consumption is calculated in a similar way as Canadian GDP.

Consumer price index (CPI)
Provincial CPI for the years 1961-1978 is taken from Di Matteo (2003) and from CANSIM Table 326-0021 for the years 1979-2006. The base years is 2002. Canadian CPI is calculated by taking average of ten provincial CPI.

Provincial population
Provincial population for the years 1961-1970 is taken from CANSIM Table 384-0035 and from Table 510-001 for the years 1971-2006. Canadian population is defined as the sum of ten provinces' population.

United State output
Real gross domestic product per capita is taken from World Development Indicators, published by the World Bank.

Figure 1: Year-by-year income and consumption smoothing

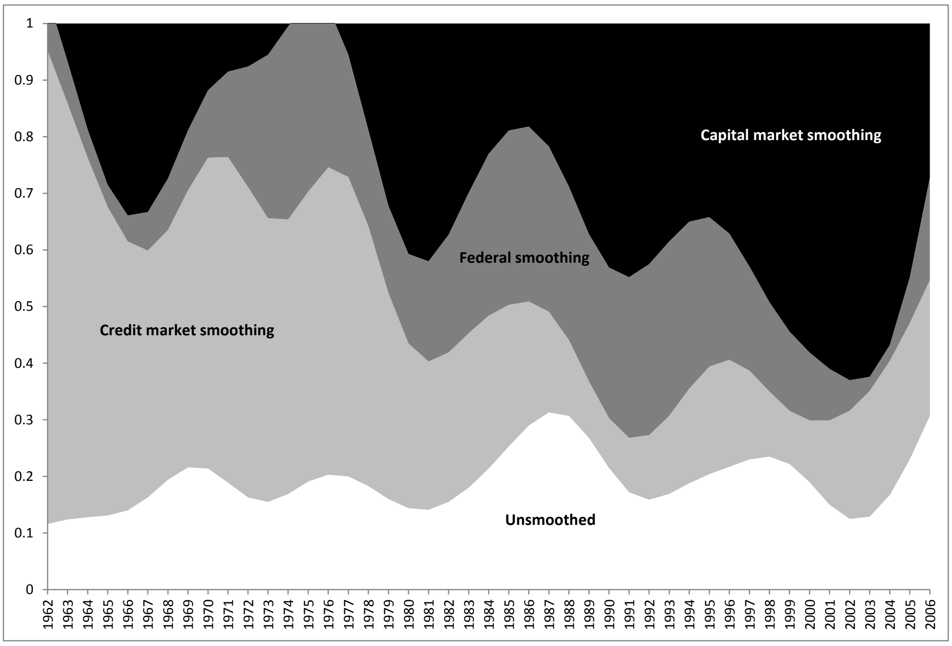

Figure 2: Real GDP per capita and growth rates: Quebec (QC) and Ontario (ON)

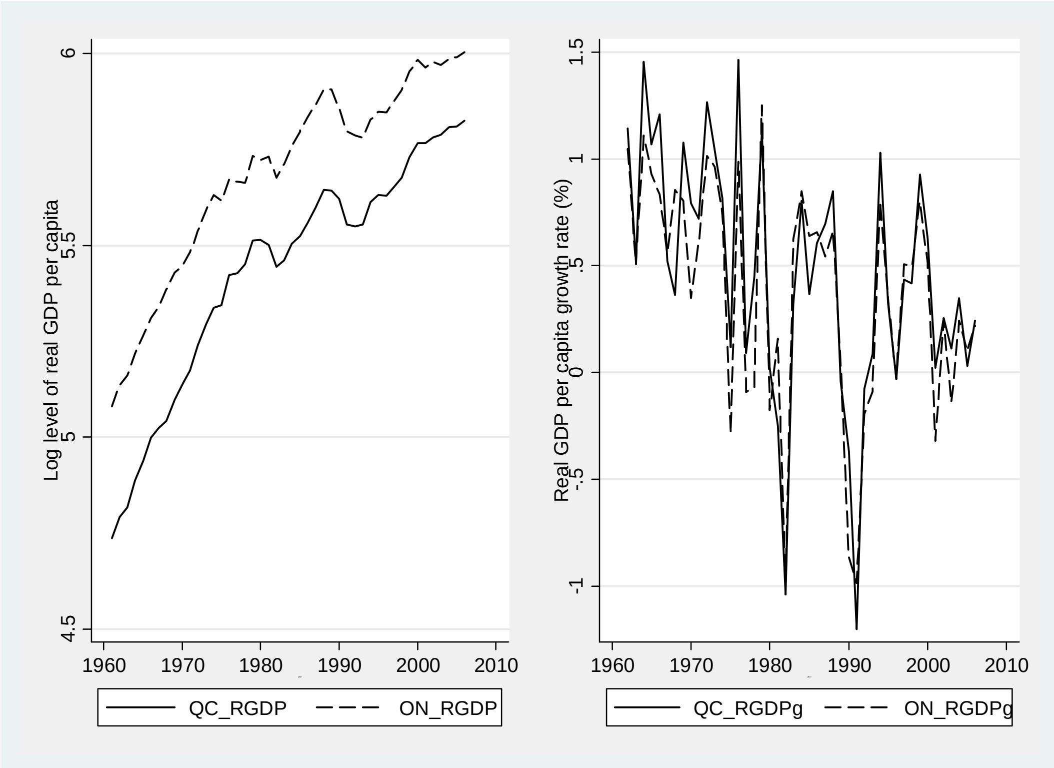

Table 1: Channels of interprovincial risk-sharing (percent): Full-sample (1962-2006)

	A. With Alberta Estimates	B. Without Alberta Estimates
Capital market (β_k)	29.20***	20.15*
	(8.74)	(10.43)
Transfers (β_f)	26.50***	20.82***
	(7.04)	(4.25)
Credit market (β_c)	23.90*	36.73***
	(11.34)	(10.98)
Not smoothed (β_u)	20.37***	22.29***
	(3.25)	(3.47)

Note: Driscoll-Kraay standard errors are in ( ). The lag length is chosen using Newey and West's (1994) plug-in procedure, $4(T/100)^{2/9}$. β_k is the slope in the regression of $\Delta \log \widetilde{\text{GPP}_i} - \Delta \log \widetilde{\text{PI}_i}$ on $\Delta \log \widetilde{\text{GPP}_i}$; β_f is the slope in the regression of $\Delta \log \widetilde{\text{PI}_i} - \Delta \log \widetilde{\text{PDI}_i}$ on $\Delta \log \widetilde{\text{GPP}_i}$; β_c is the slope in the regression of $\Delta \log \widetilde{\text{PDI}_i} - \Delta \log(\widetilde{\text{C}_i + \text{G}_i})$ on $\Delta \log \widetilde{\text{GPP}_i}$; and β_u is the slope in the regression of $\Delta \log(\widetilde{\text{C}_i + \text{G}_i})$ on $\Delta \log \widetilde{\text{GPP}_i}$. A tilde ($\sim$) over a variable denotes its log deviation from its aggregate component. For example, $\Delta \log \widetilde{\text{GPP}_{it}}$ is measured as $\Delta \log \text{GPP}_{it} - \Delta \log \text{GPP}_t$, where $\Delta \log \text{GPP}_{it}$ denotes the growth rate of province i's GPP per capita and $\Delta \log \text{GPP}_t$ denotes the growth rate of the group's aggregate GPP per capita. The β-coefficients are interpreted as the incremental percentage amounts of smoothing achieved at each level, and β_u is the amount of unsmoothed shocks. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 2: Channels of interprovincial risk-sharing (percent): Subperiods

	1962-1970	1971-1980	1981-1990	1991-2000
Capital market (β_k)	-14.57	39.76***	42.27***	57.74***
	(12.83)	(9.82)	(7.37)	(11.97)
Transfers (β_f)	10.84***	32.58*	32.52**	16.42**
	(2.64)	(16.34)	(11.76)	(6.23)
Credit market (β_c)	90.79***	4.06	5.70	4.49
	(14.70)	(15.19)	(11.90)	(8.51)
Not smoothed (β_u)	12.92***	23.59***	19.48***	21.34***
	(3.75)	(6.97)	(3.33)	(3.77)

Note: See Table 1. Driscoll-Kraay standard errors are in ( ). *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table 3: Pairwise risk-sharing via capital market channel (percent)

	β_k	Robust S.E.		β_k	Robust S.E.
NL-PE	14.38	(23.10)	NS-BC	42.54***	(6.83)
NL-NS	17.78	(31.67)	NB-QC	53.95***	(10.73)
NL-NB	49.07	(32.85)	NB-ON	71.43***	(11.13)
NL-QC	28.75	(29.35)	NB-MB	52.46**	(21.00)
NL-ON	29.11	(30.84)	NB-SK	26.12	(23.03)
NL-MB	15.40	(23.96)	NB-AB	65.20***	(5.25)
NL-SK	1.14	(18.19)	NB-BC	54.87***	(8.91)
NL-AB	40.93**	(20.22)	QC-ON	2.13	(19.68)
NL-BC	34.34	(23.26)	QC-MB	–9.71	(12.64)
PE-NS	10.98	(12.05)	QC-SK	–3.93	(12.74)
PE-NB	53.12**	(23.15)	QC-AB	67.91***	(7.26)
PE-QC	–9.68	(10.12)	QC-BC	40.91***	(7.96)
PE-ON	–4.09	(9.78)	ON-MB	–2.71	(9.43)
PE-MB	–16.40	(10.29)	ON-SK	-1.00	(12.37)
PE-SK	–2.08	(17.58)	ON-AB	66.45***	(6.00)
PE-AB	43.28***	(6.63)	ON-BC	28.94***	(8.82)
PE-BC	4.79	(10.52)	MB-SK	1.97	(11.00)
NS-NB	80.00***	(19.38)	MB-AB	65.74***	(9.90)
NS-QC	19.00	(16.32)	MB-BC	4.23	(7.91)
NS-ON	58.12***	(14.58)	SK-AB	–2.56	(10.74)
NS-MB	49.93***	(12.43)	SK-BC	–8.36	(11.58)
NS-SK	16.22	(15.59)	AB-BC	75.67***	(5.22)
NS-AB	63.48***	(7.30)			

Note: Time period is 1962–2006. Driscoll-Kraay standard errors are in ( ). β_k is the slope coefficient of the regression $(\Delta \log \text{GPP}_{ijt} - \Delta \log \text{PI}_{ijt})$ on $\Delta \log \text{GPP}_{ijt}$ and $\Delta \log z_t$, equation (6) in the text. $\Delta \log \text{GPP}_{ijt}$, for example, is measured as $\Delta(\log \text{GPP}_{it} - \log \text{GPP}_{jt})$. z_t is a vector of control variables which includes the growth rates of the Canadian output per capita and world output per capita (proxied by the United States output). For the sake of clarity, we do not report the coefficients of the control variables. Province code: NL (Newfoundland and Labrador); PE (Prince Edward Island); NS (Nova Scotia); NB (New Brunswick); QC (Quebec); ON (Ontario); MB (Manitoba); SK (Saskatchewan); AB (Alberta); BC (British Columbia). *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table 4: Pairwise risk-sharing via federal transfers channel (percent)

	β_f	Robust S.E.		β_f	Robust S.E.
NL-PE	27.91*	(15.16)	NS-BC	16.47***	(4.82)
NL-NS	34.81**	(17.80)	NB-QC	10.33**	(3.88)
NL-NB	15.88	(17.40)	NB-ON	4.89	(4.89)
NL-QC	27.94	(18.17)	NB-MB	1.89	(6.32)
NL-ON	36.81*	(19.16)	NB-SK	6.62	(5.05)
NL-MB	30.73**	(14.30)	NB-AB	21.87	(15.24)
NL-SK	17.78**	(8.49)	NB-BC	9.35**	(4.39)
NL-AB	47.28***	(16.08)	QC-ON	15.43**	(6.06)
NL-BC	32.29**	(14.44)	QC-MB	21.03***	(5.48)
PE-NS	29.76***	(7.33)	QC-SK	12.97***	(4.60)
PE-NB	8.99	(12.09)	QC-AB	41.39***	(10.67)
PE-QC	47.25***	(5.53)	QC-BC	16.07***	(4.98)
PE-ON	45.40***	(5.39)	ON-MB	23.33***	(5.88)
PE-MB	33.63***	(4.90)	ON-SK	13.71***	(3.54)
PE-SK	19.07***	(6.18)	ON-AB	36.40***	(9.60)
PE-AB	37.47***	(9.19)	ON-BC	22.30***	(5.14)
PE-BC	34.72***	(7.03)	MB-SK	10.51***	(3.03)
NS-NB	3.09	(7.64)	MB-AB	36.13***	(12.96)
NS-QC	20.29**	(8.02)	MB-BC	19.25***	(7.32)
NS-ON	10.46	(9.57)	SK-AB	11.92*	(6.77)
NS-MB	–5.34	(4.70)	SK-BC	8.62*	(4.63)
NS-SK	9.93**	(3.99)	AB-BC	49.40***	(11.28)
NS-AB	30.69***	(11.73)			

Note: Time period is 1962–2006. Driscoll-Kraay standard errors are in ( ). β_f is the slope coefficient of the regression $(\Delta \log \text{PI}_{ijt} - \Delta \log \text{PDI}_{ijt})$ on $\Delta \log \text{GPP}_{ijt}$ and $\Delta \log z_t$, equation (7) in the text. See Table 3 for further details. Province code: NL (Newfoundland and Labrador); PE (Prince Edward Island); NS (Nova Scotia); NB (New Brunswick); QC (Quebec); ON (Ontario); MB (Manitoba); SK (Saskatchewan); AB (Alberta); BC (British Columbia). *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table 5: Pairwise risk-sharing via credit market channel (percent)

	β_c	Robust S.E.		β_c	Robust S.E.
NL-PE	40.44***	(9.36)	NS-BC	8.04	(7.20)
NL-NS	31.09***	(6.68)	NB-QC	28.76***	(8.35)
NL-NB	19.61*	(10.26)	NB-ON	10.63**	(5.10)
NL-QC	22.99***	(6.34)	NB-MB	36.99***	(10.96)
NL-ON	11.21*	(6.05)	NB-SK	58.40***	(18.21)
NL-MB	36.64***	(13.01)	NB-AB	4.04	(14.33)
NL-SK	61.22***	(18.05)	NB-BC	17.18***	(4.19)
NL-AB	–4.75	(11.07)	QC-ON	27.85	(28.67)
NL-BC	7.55	(7.90)	QC-MB	64.53***	(10.11)
PE-NS	48.90***	(12.75)	QC-SK	78.53***	(17.01)
PE-NB	30.96***	(10.43)	QC-AB	–21.28*	(11.21)
PE-QC	62.57***	(9.36)	QC-BC	6.51	(11.40)
PE-ON	45.53***	(7.75)	ON-MB	47.55***	(10.63)
PE-MB	71.32***	(9.95)	ON-SK	71.38***	(16.31)
PE-SK	71.53***	(17.18)	ON-AB	–17.61*	(10.97)
PE-AB	9.39	(8.31)	ON-BC	8.10	(5.42)
PE-BC	38.91***	(8.82)	MB-SK	79.73***	(12.96)
NS-NB	5.75	(11.28)	MB-AB	–10.19	(17.59)
NS-QC	38.63***	(11.61)	MB-BC	43.70***	(11.22)
NS-ON	6.47	(9.46)	SK-AB	79.21***	(15.78)
NS-MB	47.14***	(11.32)	SK-BC	84.21***	(18.35)
NS-SK	62.37***	(16.85)	AB-BC	–37.92***	(11.51)
NS-AB	–4.78	(15.56)			

Note: Time period is 1962–2006. Driscoll-Kraay standard errors are in ( ). β_c is the slope coefficient of the regression $(\Delta \log \text{PDI}_{ijt} - \Delta \log(\text{C}_{ijt} + \text{G}_{ijt}))$ on $\Delta \log \text{GPP}_{ijt}$ and $\Delta \log z_t$, equation (8) in the text. See Table 3 for further details. Province code: NL (Newfoundland and Labrador); PE (Prince Edward Island); NS (Nova Scotia); NB (New Brunswick); QC (Quebec); ON (Ontario); MB (Manitoba); SK (Saskatchewan); AB (Alberta); BC (British Columbia). *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table 6: Unsmoothed pairwise risk-sharing (percent)

	β_u	Robust S.E.		β_u	Robust S.E.
NL-PE	17.24	(11.71)	NS-BC	32.93***	(4.25)
NL-NS	16.30	(14.82)	NB-QC	6.94	(8.90)
NL-NB	15.42	(12.09)	NB-ON	13.03	(10.02)
NL-QC	20.30	(13.20)	NB-MB	8.64	(8.11)
NL-ON	22.85*	(11.97)	NB-SK	8.84	(5.77)
NL-MB	17.21	(10.59)	NB-AB	8.87*	(4.69)
NL-SK	19.83***	(5.59)	NB-BC	18.57**	(7.88)
NL-AB	16.53**	(7.03)	QC-ON	54.58***	(18.63)
NL-BC	25.80***	(8.91)	QC-MB	24.15***	(5.77)
PE-NS	10.35	(6.40)	QC-SK	12.42**	(5.83)
PE-NB	6.91	(6.26)	QC-AB	11.97***	(3.87)
PE-QC	–0.14	(6.51)	QC-BC	36.49***	(9.47)
PE-ON	13.15**	(5.75)	ON-MB	31.82***	(6.25)
PE-MB	11.45**	(5.22)	ON-SK	15.90***	(5.20)
PE-SK	11.47*	(6.83)	ON-AB	14.75***	(3.73)
PE-AB	9.84***	(3.67)	ON-BC	40.65***	(6.59)
PE-BC	21.55***	(7.69)	MB-SK	7.77**	(3.37)
NS-NB	11.13	(7.80)	MB-AB	8.31**	(3.51)
NS-QC	22.06***	(4.99)	MB-BC	32.80***	(7.93)
NS-ON	24.93***	(5.97)	SK-AB	11.43***	(3.84)
NS-MB	8.26	(5.91)	SK-BC	15.52***	(5.82)
NS-SK	11.47***	(3.31)	AB-BC	12.84***	(3.82)
NS-AB	10.59***	(2.99)			

Note: Time period is 1962–2006. Driscoll-Kraay standard errors are in ( ). β_u is the slope coefficient of the regression $\Delta \log(\textsc{c}_{ijt}+\textsc{g}_{ijt})$ on $\Delta \log \textsc{gpp}_{ijt}$ and $\Delta \log z_t$, equation (9) in the text. See Table 3 for further details. Province code: NL (Newfoundland and Labrador); PE (Prince Edward Island); NS (Nova Scotia); NB (New Brunswick); QC (Quebec); ON (Ontario); MB (Manitoba); SK (Saskatchewan); AB (Alberta); BC (British Columbia). *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table 7: Extent of income and consumption smoothing (percent)

Provinces	β_k	β_f	β_c	β_u
NL	11.06	33.02***	7.54	48.36***
	(6.70)	(9.44)	(10.49)	(4.41)
PE	19.13**	34.28***	–2.52	49.10***
	(8.70)	(8.47)	(10.11)	(4.34)
NS	22.66***	32.57***	5.22	39.53***
	(5.46)	(7.57)	(9.09)	(4.54)
NB	15.55**	31.27***	3.04	50.12***
	(7.06)	(9.42)	(10.32)	(5.40)
QC	15.25**	36.42***	8.65	39.66***
	(7.22)	(8.57)	(10.25)	(5.84)
ON	14.55*	34.76***	5.27	45.41***
	(7.23)	(9.36)	(9.00)	(5.87)
MB	14.94**	33.03***	9.47	42.54***
	(6.91)	(9.73)	(9.71)	(5.55)
SK	17.54**	23.14**	11.48	47.82***
	(8.94)	(9.88)	(9.95)	(7.65)
AB	5.88	28.29***	22.58**	43.24***
	(10.62)	(10.99)	(10.91)	(8.06)
BC	15.64***	33.60***	4.88	45.86***
	(5.38)	(9.97)	(9.51)	(6.66)

Note: Time period is 1962–2006. Driscoll-Kraay standard errors are in ( ). The β-coefficients are interpreted as the fraction of shocks smoothed by a particular province with the rest of Canada, and β_u is the amount of unsmoothed shocks. β_k is the slope coefficient of the regression $(\Delta \log \text{GPP}_{ijt} - \Delta \log \text{PI}_{ijt})$ on $\Delta \log \text{GPP}_{ijt}$ and $\Delta \log z_t$; β_f is the slope coefficient of the regression $(\Delta \log \text{PI}_{ijt} - \Delta \log \text{PDI}_{ijt})$ on $\Delta \log \text{GPP}_{ijt}$ and $\Delta \log z_t$; β_c is the slope coefficient of the regression $(\Delta \log \text{PDI}_{ijt} - \Delta \log(\text{C}_{ijt} + \text{G}_{ijt}))$ on $\Delta \log \text{GPP}_{ijt}$ and $\Delta \log z_t$; and β_u is the slope coefficient of the regression $\Delta \log(\text{C}_{ijt} + \text{G}_{ijt})$ on $\Delta \log \text{GPP}_{ijt}$ and $\Delta \log z_t$. $\Delta \log \text{GPP}_{ijt}$, for example, is measured as $\Delta(\log \text{GPP}_{it} - \log \text{GPP}_{jt})$, where i refers to province i and j is defined as $N-1$ (rest of Canada), and N is the number of Canadian provinces. z_t denotes growth rate of the world output per capita (proxied by the United States output). For the sake of clarity, we do not report the coefficient of the control variable. Province code: NL (Newfoundland and Labrador); PE (Prince Edward Island); NS (Nova Scotia); NB (New Brunswick); QC (Quebec); ON (Ontario); MB (Manitoba); SK (Saskatchewan); AB (Alberta); BC (British Columbia). *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.